Characterization of Nighttime Light Variability Over the Southeastern United States

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Introduction & Motivation

- City lights provide indications of human activity at night
- Nighttime satellite imagery offers daily snapshots of this activity
- With calibrated, science-quality imagery, long-term monitoring can also be achieved
- The degree to which city lights fluctuate, however, is not well known
- For the application of detecting power outages, this degree of variability is crucial for assessing reductions to city lights based on historical trends
- Eight southeastern U.S. cities are analyzed to understand the relationship between emission variability and several population centers
- A preliminary, example case power outage study is also discussed as a transition into future work

http://earthobservatory.nasa.gov/blogs/earthmatters/files/2013/05/BJIsY4ACUAAfrtq.jpg_large.jpg

http://si.wsj.net/public/resources/images/BN-FL283_1107na_J_20141107144335.jpg

Science Application

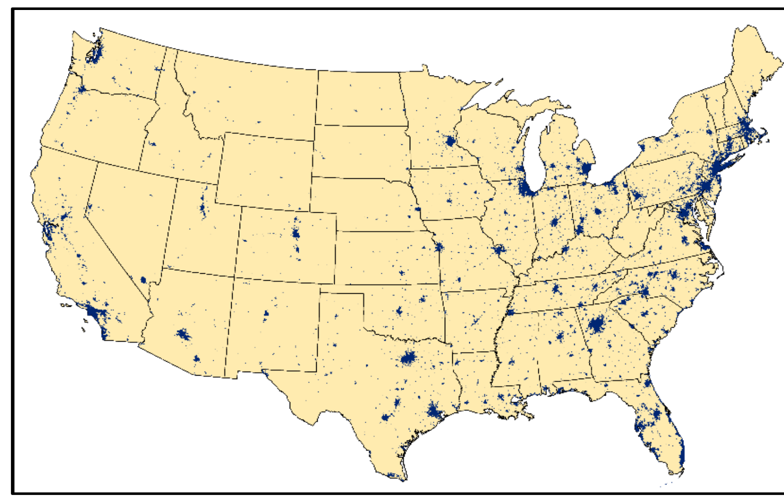
- Detecting power outages during disaster events can provide first responders an overview of damage
- Detection of power outages requires a thorough understanding of “normal” nighttime light variability
- With the degree of variability known, any reduction following a severe weather event can be classified by statistical significance
- An example approach is to generate multi-image, pre-event composites which can be compared against post-event, single image arrays to determine percent of normal emissions
- If generated in near real-time (NRT), a power outage detection product would benefit disaster response efforts by providing a spatial estimate of damage following severe weather

http://i.huffpost.com/gen/846503/thumbs/o-NY-MAG-570.jpg?4

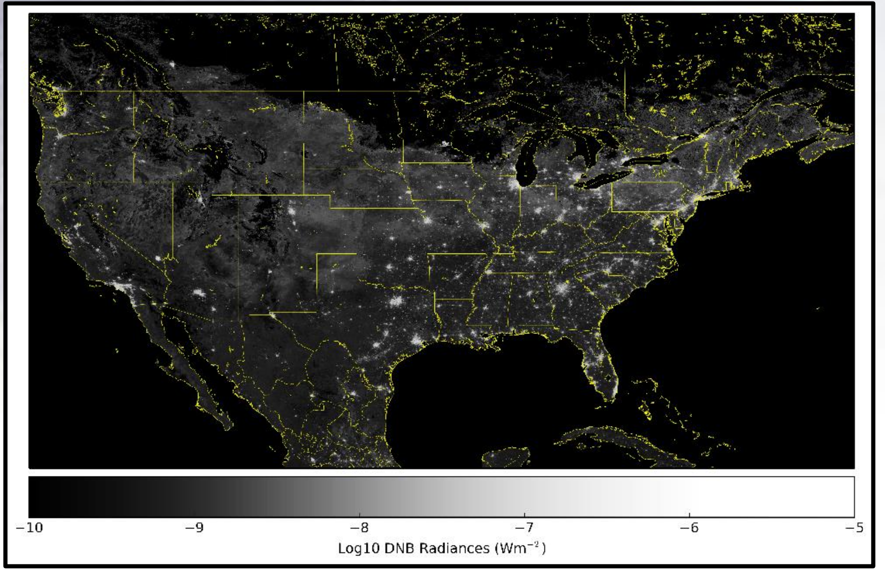
Data

- The VIIRS Day/Night Band (DNB) can detect nighttime emissions from cities, natural gas flares, lightning and boats
- Through collaboration with Dr. Miguel Román at Goddard Space Flight Center (GSFC), a 1 km gridded DNB product which isolates city light emissions was acquired (Román et al. 2015)
- This product serves as the historical archive of city light emissions and a baseline for monitoring their variability over time
- Nightly data was acquired for: Jan. 19, 2012 – Sept. 10, 2015
- Individual city extents were masked from the DNB data using the 2014 U.S. Census Metropolitan Statistical Area (MSA) shapefile

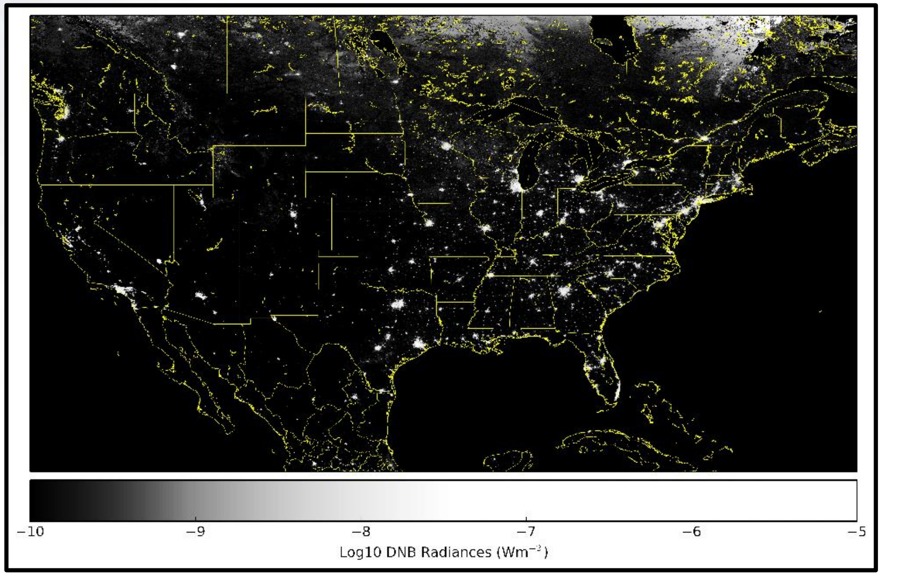
https://www.nasa.gov/sites/default/files/images/712129main_8247975848_88635d38a1_o.jpg



CONUS Composite Imagery

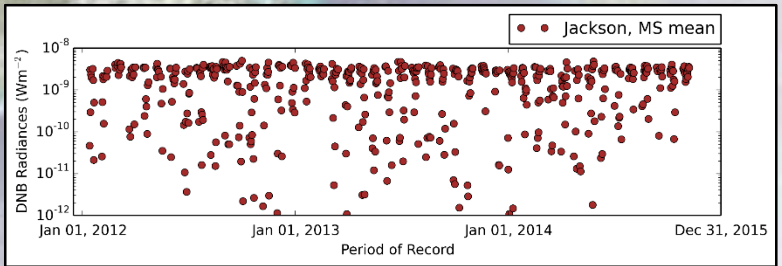


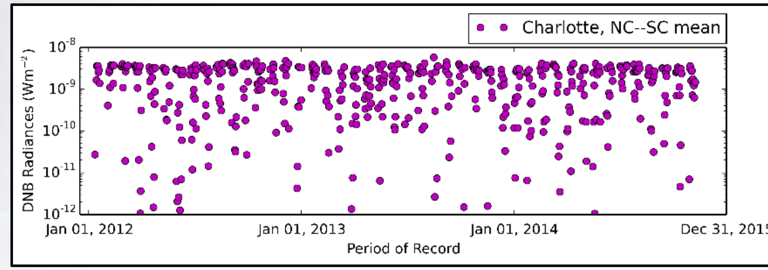
2013 Mean pixel composite of highest quality, snow- and cloud-free observations

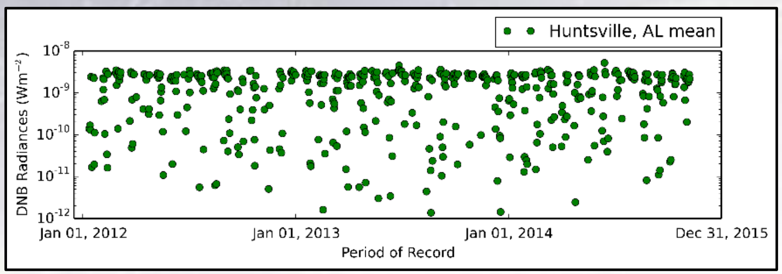


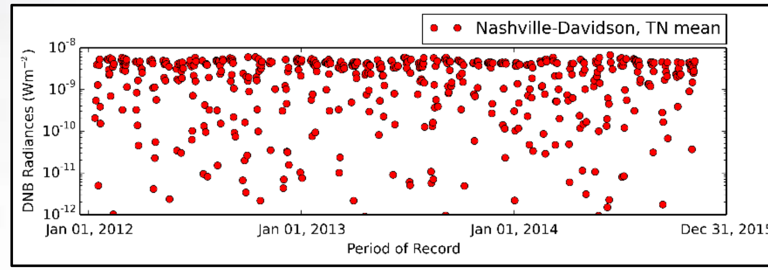
2013 Minimum pixel composite of highest quality, snow- and cloud-free observations

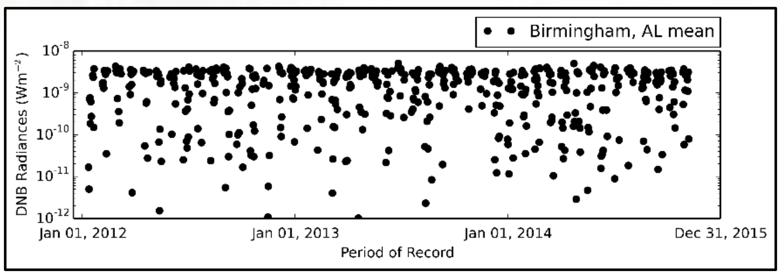
Variability in the Southeastern United States

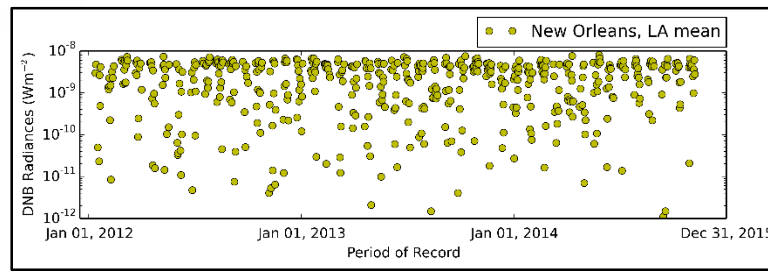


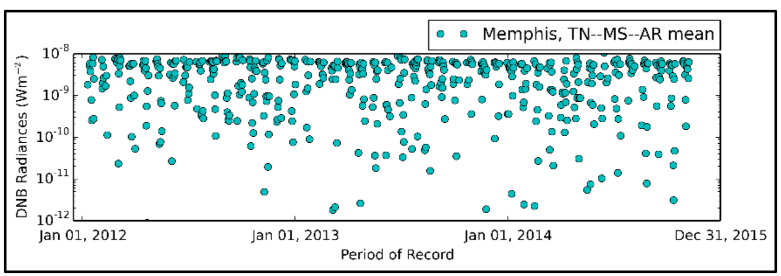


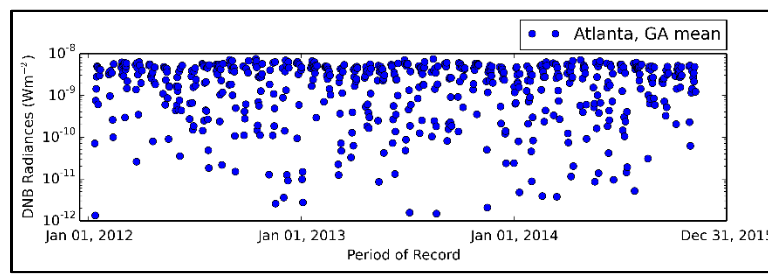






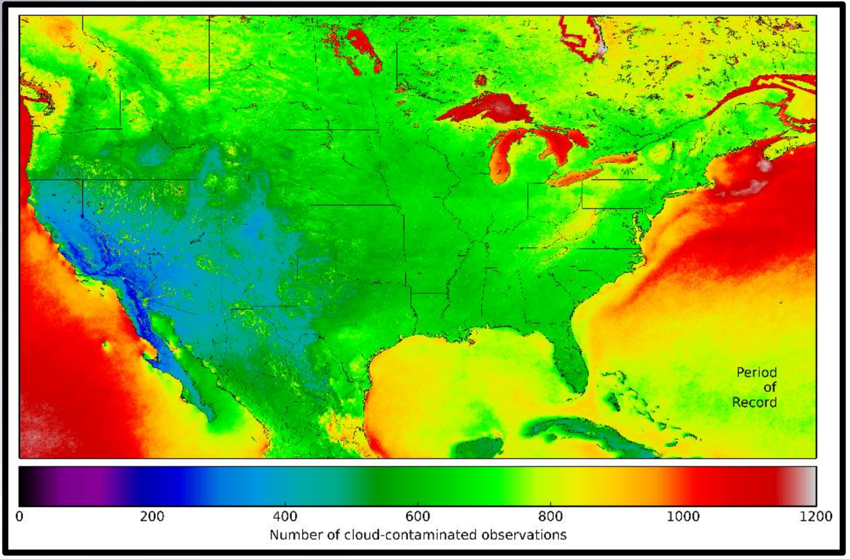


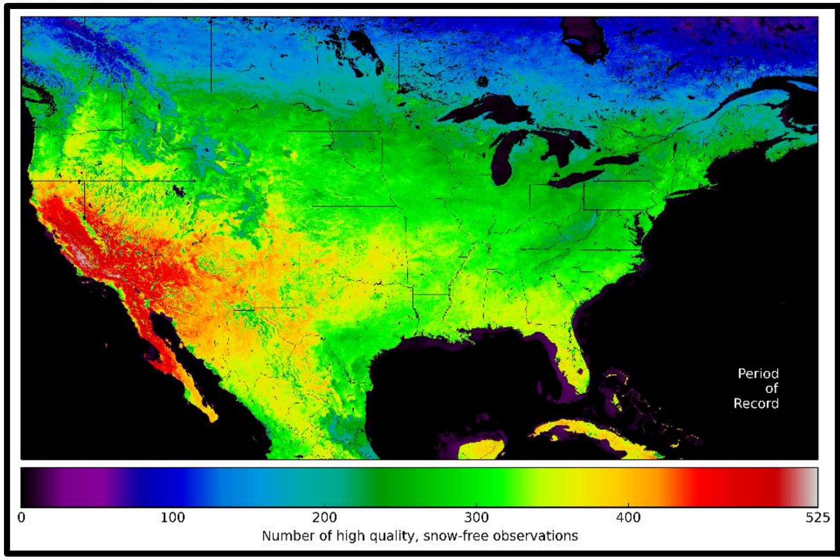


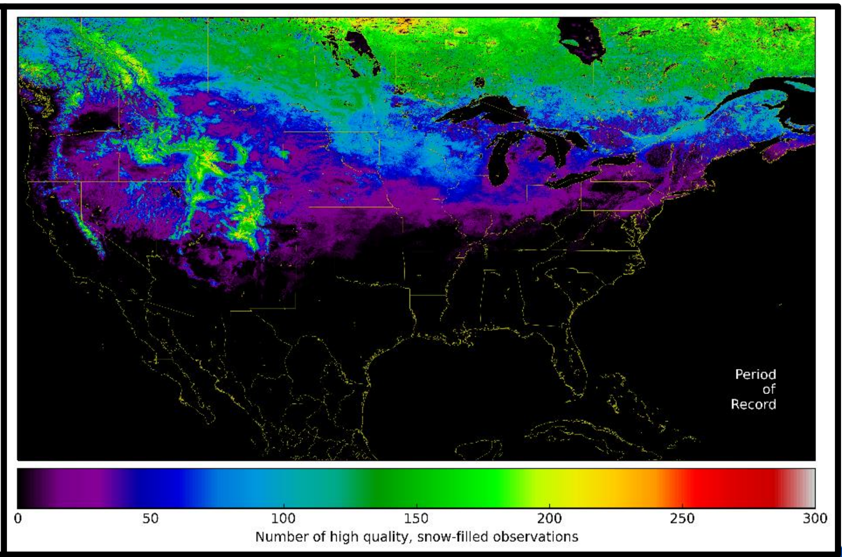


Transitioning unique data and research technologies to operations

Data Quality





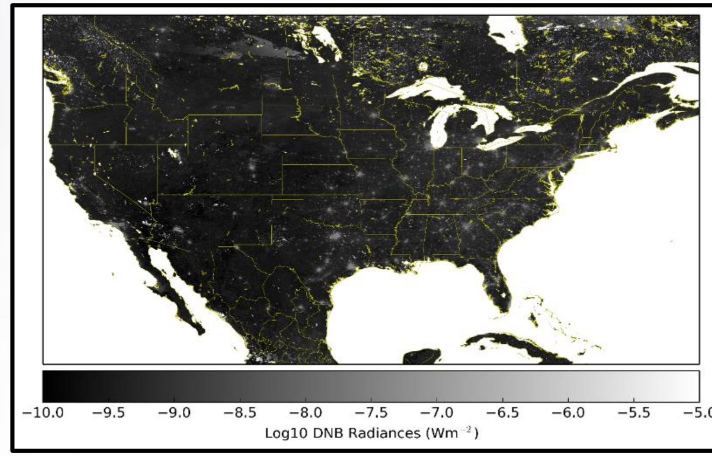


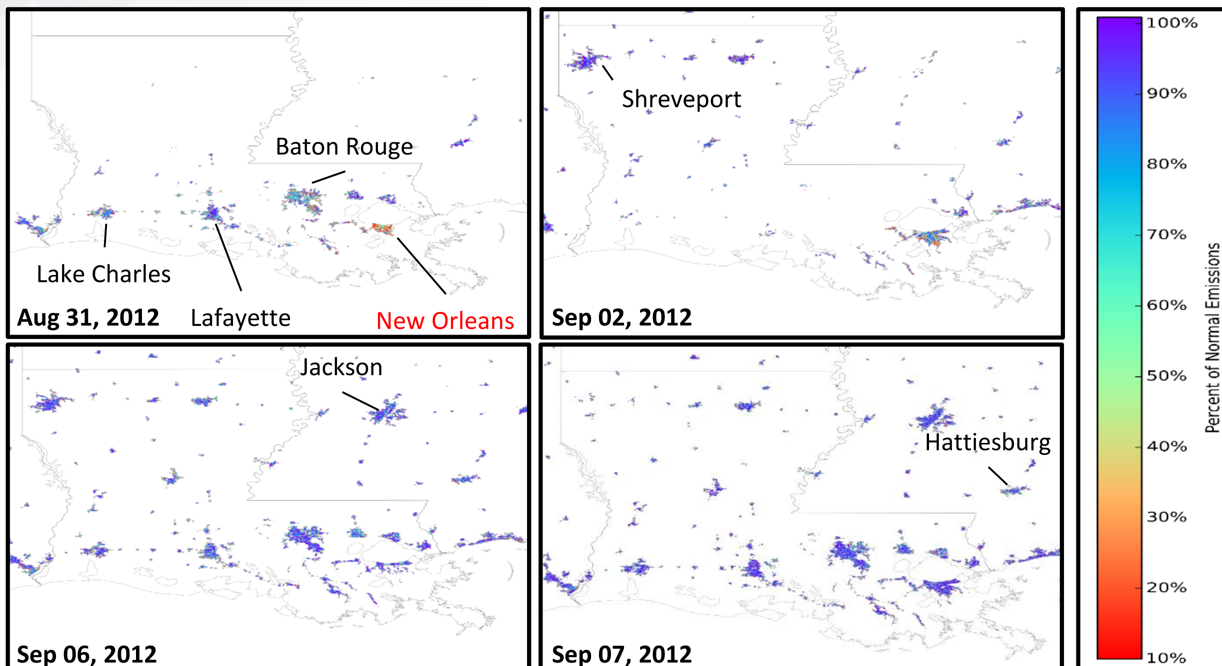
Example Power Outage Case Study

- Hurricane Isaac made landfall in Louisiana on August 29th, 2012
- Along with strong winds and damaging rains, power was disrupted for an estimated 890,000 customers
- By compositing 30 pre-event images, a baseline is computed as “normal” lights
- Single, post-event images can then be used to detect damage and monitor recovery
- A pixel-based, percent of “normal” is computed by:

$$Percent_{normal} = 100 * \left(\frac{Post}{Pre}\right),$$

where **post** is a single cloud-free, post-event image and **pre** is a 30-day running mean composite





Conclusions

- City lights provide insights to human activity at night
- Understanding how city lights fluctuate over time is vital to understanding the statistical significance of any reductions due to severe weather
- The VIIRS DNB has potential for use to monitor these features
- Preliminary variability trends over nearly four years are shown for eight cities in the southeastern U.S.
- A method is proposed to detect reductions in lights by comparing cloud-free, post-event single images to a 30-day, pre-event image composite

Future Work

- Alternative approaches for analyzing city light variability such as standard deviation of observations will be explored
- Quantifying reductions after severe weather events through departures from a pre-event sigma could improve detection
- A spatial data set of documented power outages following a severe weather event would provide an opportunity for validating estimates like those shown above

Questions?

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http://weather.msfc.nasa.gov/sport/